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Study on Effects of Viscosity on Multispectral Phase-contrast Imaging of Acoustic Impedance

粘性が音響インピーダンス・マルチスペクトル位相差画像法に与える影響の検討

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1. Introduction

Pathological diagnosis using the optical method currently performed in the clinical field invites an increase in the operation time and the number of operations, which is a heavy burden on both the patient and the clinical field. Therefore, in order to realize minimally invasive and real-time pathological diagnosis, we have been developing a puncture needle-type ultrasonography.[1–7] By using ultrasonic waves, it is not necessary to stain, and real time diagnosis is possible. In addition, it is possible to directly measure tissue with minimal invasiveness in vivo.

In order to perform pathological diagnosis using ultrasonic waves, it is necessary to know the properties of tissues from measured ultrasonic signals. Therefore, a multispectral phase-contrast imaging of acoustic impedance was proposed.[5–7] In this method, we expected to investigate the frequency dependence of tissue from the contrast of color images obtained by superimposing images acquired at multiple frequencies. So far, it has been reported by simulation that the amplitude and the phase of the reflected signal of the ultrasonic wave from the sample surface change because of the difference in the viscosity of the samples.[7] In this study, the reflected signals of the ultrasonic wave from the surface of the samples with different viscocities were experimentally measured, and the effects of the viscosity on the phase of the reflected signals were investigated.

2. Principle

Figure 1 shows the procedure of the interference-based acoustic impedance measurement method.[4] When a burst signal is transmitted from the PZT, it is reflected at the end of the rod sensor and the surface of the sample. These reflected signals interfere with each other. This interference wave is varied as a function of the distance between the rod sensor and the surface of the sample. An example of the interference pattern is shown in **Fig. 2**.

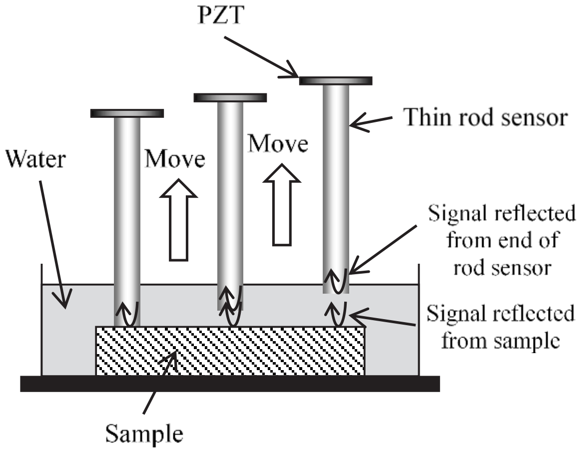

Fig. 1. Procedure of interference-based acoustic impedance measurement method.

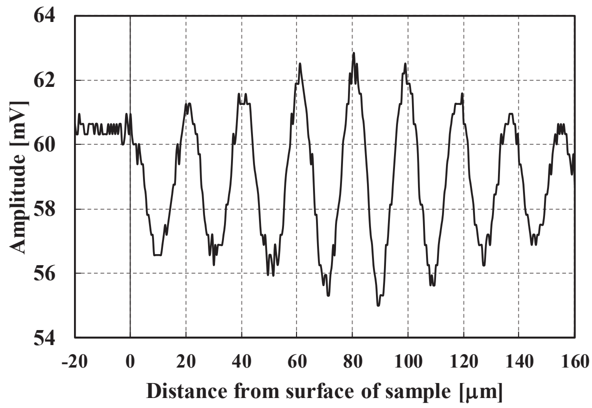

Fig. 2. Example of interference pattern.

3. Experiment

Figure 3 shows a schematic diagram of the experimental setup. In this experiment, a fused quartz rod having a diameter of 1.1 mm and a length of 62 mm was connected to a transducer having a center frequency of 38.7 MHz. The tip of the rod had a concave spherical surface. Three electrical burst waves with an amplitude of 10 $V_{p\text{-}p}$, frequencies of 34.1 MHz, 41.0 MHz, and 47.8 MHz, and a pulse

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width of 20 cycles were applied. Three types of silicone oil with viscosities of 100 cP, 12500 cP, and 100000 cP were used as a sample. We measured the interference pattern by changing the viscosity of the sample and compared their phases.

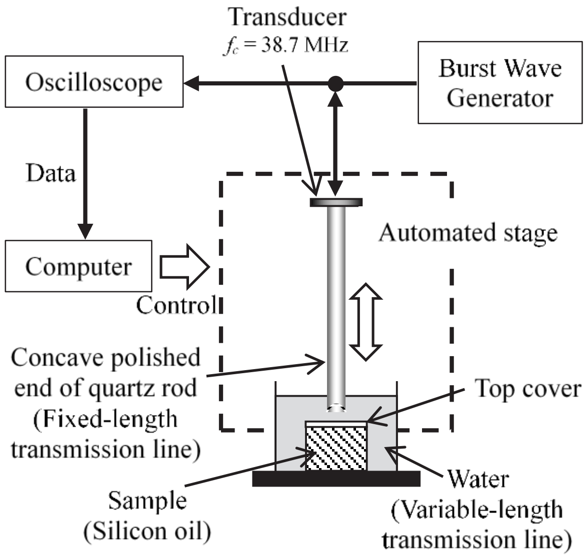

Fig. 3. Schematic diagram of experiment.

4. Results and Discussion

Figure 4 shows the amplitude of the interference signal as a function of the distance between the end of the quartz rod and the top cover of the sample. In all measurement frequencies, as the viscosity changes, the phase of the interference wave also shifts. This trend agrees with the result of previous simulation.[7]

From this result, it was confirmed that the difference in the viscosity of the sample affects the phase of the measurement signal. Therefore, in the multispectral phase-contrast imaging of acoustic impedance, the difference in viscosity is a factor that causes a difference in the contrast of the image.

5. Conclusion

In order to realize a pathological diagnosis using ultrasonic waves, we investigated the effects of the viscosity on the phase of the interference signals by experiment. From this, we experimentally confirmed that the viscosity of the sample affects the phase of the measured interference wave in the multispectral phase-contrast imaging of acoustic impedance.

References

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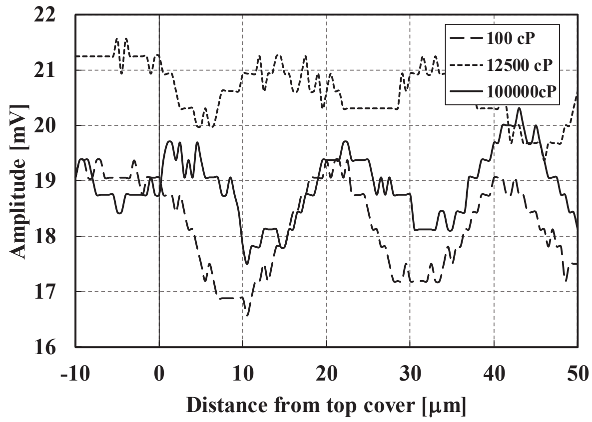
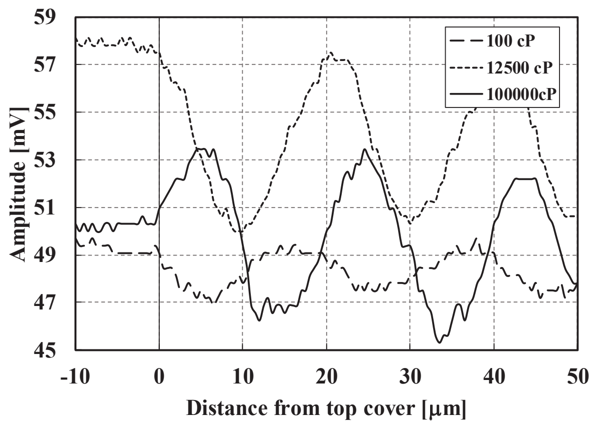
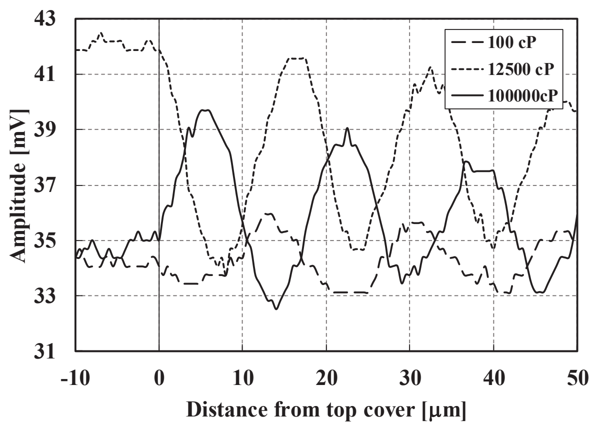


(a) Electrical burst wave with 34.1 MHz



(b) Electrical burst wave with 41.0 MHz



(c) Electrical burst wave with 47.8 MHz

Fig. 4. Amplitude of interference signal as a function of distance from top cover.